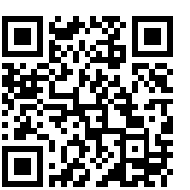
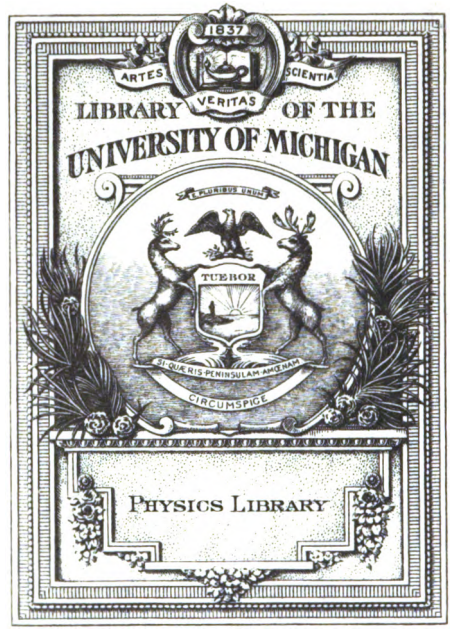


KELVIN CENTENARY ORATION AND ADDRESSES COMMEMORATIVE



KELVIN CENTENARY
ORATION AND ADDRESSES
COMMEMORATIVE

From the Painting in the Council Room of the Institution of Electrical Engineers

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KELVIN CENTENARY ORATION and ADDRESSES COMMEMORATIVE

Kelvin centenary committee

London
Percy Lund Humphries & Co Ltd
3 Amen Corner E.C.4
1924

Made and Printed in Great Britain

FOREWORD

WILLIAM THOMSON, LORD KELVIN, was born one hundred years ago on June 26th, 1824. Arrangements were made by a committee, convened by the Royal Society, to celebrate the Centenary of his birth in a manner befitting the memory of one to whose achievements mankind are so greatly indebted. The Committee contained representatives of the Royal Society, the Institutions of Civil, Mechanical and Electrical Engineers, the Physical Society, and other technical bodies, as well as of the universities with which LORD KELVIN was connected. A Council of Honour representative of scientific and technical bodies in all parts of the world was also formed.

The celebrations were held in London on July 10th and 11th, 1924. They included a meeting on the 10th held at the Institution of Civil Engineers, at which Sir J. J. Thomson delivered a Memorial Oration; and at which delegates from beyond seas to the Council of Honour presented congratulatory addresses. An exhibition of KELVIN experimental apparatus was also displayed on this occasion. A banquet was held on July 11th with the Rt. Hon. the Earl of Balfour in the chair, which provided an opportunity for the gathering of many distinguished scientists and engineers from all parts of the world.

The Kelvin Oration of Sir J. J. Thomson, the memorial addresses presented on the 10th, and the speeches at the banquet on the 11th, are published in this Commemorative volume, which has been printed for the benefit of those who, in many lands, may wish to possess a record of this great tribute, unique in its form and world-wide character, to the memory of LORD KELVIN.

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HELD

JULY 10TH

1924

CHAIRMAN'S INTRODUCTION

BY SIR RICHARD GLAZEBROOK, K.C.B
CHAIRMAN: KELVIN CENTENARY COMMITTEE

SIR RICHARD GLAZEBROOK: William Thomson, Lord Kelvin, was born on the 26th June, 1824, and that is the reason for our meeting to-day. In the hundred years that have passed the progress of the world has been great, changes have been many, and we have gone forward; and towards that progress there are few men—may I say there is no man—who has contributed more than Lord Kelvin, whose memory we are commemorating to-day. The Kelvin Orator will tell you in a few moments why that is, and will explain some of the reasons, perhaps, which call out from us our gratitude in connection with his memory. I have a lighter task. I may be permitted in the first instance just to explain how this Centenary Meeting came to be. Attention was drawn, I think in the first instance by Dr. Russell, the President of the Institution of Electrical Engineers, to the fact that this year we were to celebrate the Kelvin Centenary, and the Royal Society invited a number of the other great societies of the engineering and technical world to join with them in forming the Kelvin Centenary Committee. The bodies that are represented on that Committee are: the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Institution of Electrical Engineers, the Institution of Naval Architects, the Physical Society, and the Universities of Cambridge and Glasgow, and the Royal Society of Edinburgh. Those are bodies that were asked in the first instance by the Royal Society to co-operate in bringing about this ceremony. As Chairman of that Committee, by the kindness of the President of the Royal Society, Sir Charles Sherrington, I am here to-day as the representative

of that Committee, and of the Society, to welcome the large body of delegates who have come from all quarters of the world to do honour to our great master, Lord Kelvin (cheers). Allow me to do that most cordially and most heartily. The Kelvin Medallist has told us how from his earliest years Lord Kelvin was his hero and his ideal. There are many of us in this room and many sitting round this table that can claim the same. To all of us Britishers, it is a fact that we derive enormous pleasure from the fact that the merits of Kelvin should be recognised, as they obviously are, by this large body of delegates from overseas and from every British institution. You have the list before you. There are some whose names are on the list who unfortunately have been prevented from being present, and perhaps I may mention one or two of them. I should mention in the first place, perhaps, Dr. Robert A. Millikan, who represents the National Research Council of the United States of America. His work, I am sure, is very well known. It was a source of real pleasure and gratitude to us on the committee when we heard that the famous Institut of France was to be represented by its distinguished secretary, Prof. Emile Picard, and it was a source of great regret when, two days ago, I received a letter from Prof. Picard to the effect that his health prevented him from crossing the Channel. Then there is Prof. Lorentz, of Holland, who is not able to be present. I am to have the privilege of receiving from many of our visitors, Addresses, in which they express their appreciation of Kelvin's work, and of all that he did. Time will not allow us to read all those Addresses, but permit me to quote a few lines from one which came from Russia three days ago: "Kelvin's work and ideas," the Russian Academy say, and they have had a special session to commemorate Kelvin and his work, "Kelvin's work and ideas have given us a new conception of the universe, unifying

the different branches of the science of Nature. We see in him the great mathematician, one of the greatest scholars in physics, a philosopher, a man of technical application and of scientific discoveries. His creative power applied these splendid achievements to the technical uses of our common life." Those words of the Russian Academy seem to me to express concisely the feelings of all of us. But I am trespassing on the sphere of Sir Joseph Thomson, who is to-day the most admirable representative of Professor Picard, who is unable to be present. Let me again thank our visitors for their presence here, and proceed in accordance with the programme. I am going to invite the delegates from across the seas to hand to me the Addresses they have been good enough to bring, in order that I may have the opportunity and pleasure of thanking each of them personally, and Institutions they represent, for their kindness in coming. Our British delegates will realise, I think, that time is short, and will, perhaps, be content to leave their Addresses with me after the meeting. I thank them all collectively for their presence here, and for the honour they wish to do to the memory of Kelvin.

Memorial Addresses were then presented by delegates from Societies in the British Dominions and Foreign Countries. These are printed *in extenso* on pages 53 to 94 of this volume.

SIR RICHARD GLAZEBROOK: I should like to mention that Professor Tanakadate has come all the way from Japan to do honour to his master, Lord Kelvin. I renew my thanks to those who are present to-day, and who have brought these numerous Addresses to Lord Kelvin's memory. We now come to the Kelvin Oration.

Sir Joseph Thomson needs no introduction from me. We have been fortunate—I am sure you will all

agree—in securing his services as Kelvin Orator to-day. He is the man of all others in the world, who can tell us what we owe to Kelvin, who can appreciate the magnitude of the work Kelvin did, and who can instruct us as to the consequences that followed from that work. Not only that. As a friend of Kelvin, he can tell us of those intimate qualities that endeared Kelvin to us not merely as a great leader in science, not merely as a teacher, but as a revered friend. I now ask Sir J. J. Thomson to deliver his Address.

SIR JOSEPH J. THOMSON, O.M., F.R.S., then delivered the Kelvin Oration.

THE KELVIN ORATION

BY SIR J. J. THOMSON, O.M., F.R.S

WE meet here to-day to celebrate the centenary of the birth of William Thomson, Lord Kelvin, the Admirable Crichton of the physical sciences, a great physicist, a great mathematician and a great engineer. Some slight idea of the scope and success of his activities may be gathered from the list of the societies over which he had presided at one time or another. He had been three times President of the Institution of Electrical Engineers, President of the Royal Society, of the Mathematical Society, of the Physical Society, of the Faraday Society and of the Institute of Marine Engineers. Never was so great a physicist, so great an engineer. He was an inventor as well as a discoverer and took out patents as readily as he wrote papers. His personality was as much an inspiration for the engineer as it was for the physicist, and was so marked and unforgettable that, to those here who knew him, there may seem something almost unnatural in this celebration. A centenary connotes something remote, a memory that has to be revived: I think that the

recollection of those who knew Lord Kelvin is so vivid that no centenary, no memorials, are required to keep it green.

Few men of science have sprung into fame at such an early age as Lord Kelvin—his precocity was remarkable. He was born on June 26th, 1824, at Belfast, where his father, James Thomson, was professor of mathematics in the Royal Belfast Academical Institution. In 1832 James Thomson was appointed professor of mathematics at the University of Glasgow, and William Thomson's life-long connection with that city and university began. His education was as exceptional as most things in his career; he was educated at home by his father and went to the University of Glasgow when he was only ten years old; he not only went to the university, but, before he was eleven, he won two prizes in the "Humanity" class; he took the College prizes in mathematics and natural philosophy, and also in logic when he was thirteen. His idea of the education suitable for a boy of twelve, given in a speech made only a few months before his death, is evidently based on his own experience; he says, "a boy should have learned by the age of twelve to write his own language with accuracy and some elegance; he should

have a reading knowledge of French, should be able to translate Latin and easy Greek authors, and should have some acquaintance with German. Having learned thus the meaning of words, a boy should study logic"—this, I think, must be the most optimistic scheme of juvenile education ever put forward.

During his last year as a student at Glasgow his thoughts were turned almost by chance to two subjects which were destined to occupy a good deal of his attention for the next sixty years: these were the Figure of the Earth and Fourier's Theorem. The first was set for a College Essay Prize; he won the prize with an essay so complete that he kept it throughout his life and referred to it from time to time when he wished to revive his memory of the literature of the subject: the last reference was only a few months before his death. His introduction to Fourier's Theorem may be given in his own words. "The origin of my devotion to these problems is that, after I had attended in 1839, Nicholls' senior philosophy class, I had become filled with the utmost admiration for the splendour and poetry of Fourier. I asked Nicholls if he thought I could read Fourier. He replied, 'Perhaps.' So on

the first of May, 1840, I took Fourier out of the university library and in a fortnight I had mastered it, gone right through it."

Lord Kelvin was faithful to his first loves, for I have heard him say, though I think few will agree with the first statement, that his work on problems connected with the Earth was his most important contribution to physics, and that whenever he had done anything with which he felt particularly pleased, Fourier's Theorem was always at the bottom of it. His first paper, published in the Cambridge Mathematical Journal for May, 1841, over the signature P.Q.R. was on Fourier's "Expansion of Functions." In the following October, William Thomson came into residence at Peterhouse, Cambridge. The news soon got about that a freshman had come up who had written a paper about Fourier's Theorem, a subject regarded as so abstruse that there had been a question as to whether it ought to be included in the Mathematical Tripos at all, and within a short time of his coming up to Cambridge, he was recognised as the best mathematician of his year. During his undergraduate days, besides reading mathematics with Hopkins—a great teacher and a great mathematician—and

writing some mathematical papers, he played on the French horn, was President of the University Musical Society, boated and won the Colquhoun Sculls. The examination for the Mathematical Tripos took place in January, 1845. Thomson was expected by the majority of undergraduates and teachers to be Senior Wrangler, though there were rumours of a dark horse who could write out answers to mathematical questions with great accuracy and prodigious rapidity. The honour this time fell to the fleet rather than to the strong, and Parkinson of John's was Senior Wrangler with Thomson second. In the examination for the Smith's Prizes which took place a few weeks after the Tripos examination and where much more time was allowed for answering the questions, Thomson was easily first. Immediately after taking his degree, he went to Paris and spent two months working in Regnault's laboratory and seeing much of the great French mathematicians, Cauchy and Liouville. This visit had a great influence on his career ; it seems to have arisen from a desire to get some experience of experimental physics with the view of strengthening his claims for the Chair of Natural Philosophy at Glasgow, which it was expected would soon become

vacant. In these days, when such emphasis is laid on a long and elaborate training in experimental physics for our students, it is interesting to note that these few weeks in Regnault's laboratory seem to have been all the preparatory training that Lord Kelvin ever had in what is now called practical physics.

The great value of this training is, that for some students, it seems the only way by which they can get a good grip of the theory; much of it is superfluous to those who, like Kelvin, require no assistance in understanding the theory and who have patience, carefulness and some skill in manipulation.

But in addition to the growth of his interest in physics by his work in the laboratory and the stimulus from his conversation with the French mathematicians, a still more important result as far as his future work was concerned was, that it was in Regnault's laboratory that his attention was directed to Sadi Carnot's work on the Motive Power of Heat. Carnot's work, from which the Second Law of Thermodynamics arose, was published the year Lord Kelvin was born, so that 1924 is the centenary of the birth of the Second Law of Thermodynamics, as well as of Lord Kelvin, who did

so much to develop it. In 1846, the long expected vacancy in the Chair of Natural Philosophy at Glasgow took place, and William Thomson was elected in October, when he was 22 years of age, to the professorship which he held for 53 years. He had a good deal of work to get things into any kind of order. He says, "When I entered upon the Professorship of Natural Philosophy at Glasgow, there was absolutely no provision of any kind for experimental investigation, still less idea even for anything like students' practical work." The laboratory was not extensive, for even as late as the sixties it was described by Professor Ayrton as consisting of one room and the adjoining coal cellar; primitive as it was it seems to have been the first laboratory in the country where experiments were made by the students. As a teacher, William Thomson was more successful as an inspirer than as an instructor; he filled the ablest men with enthusiasm, the others with something like despair. He was apt to wander away from the schedule into the subject which was interesting him at the moment.

The years following his appointment to the professorship were, I think, the most fruitful

of his long career. The decade 1850-1860 saw the establishment of the Second Law of Thermodynamics, and his work in this connection has, I think, a good claim to be regarded as the most important of his many important contributions to physics. The position at the beginning of this period was one of perplexity. Carnot's most fruitful idea, of a reversible engine and the corollary that when a given quantity of heat goes through such an engine the amount of work done by it is independent of the working substance, was generally accepted. Carnot, when he wrote his paper, held the view that heat was a fluid, and compared a heat engine with a water one, the heat engine getting its energy by the fall of this fluid from a high temperature to a low, just as a water engine gets its energy by the fall of water from a high to a lower level. As the amount of water that comes out of the water engine is the same as that which goes in, so in the heat engine it was supposed that the amount of heat given to the condenser was the same as that taken from the boiler. This was contradictory to the principle of the Conservation of Energy which was coming into prominence as the result of the work of Joule and Meyer; for on this principle,

if work is done, heat must be lost. So firmly did Thomson believe in the Carnot principle and so keenly did he feel its importance that he refused for a long time to accept the conclusions which his friend Joule drew from his experiments. A great step was made in 1850, when Clausius pointed out that by far the most important conclusions to be drawn from Carnot's principle remain unaffected even if we suppose that, as the Conservation of Energy requires, the heat given to the refrigerator is less than that taken from the boiler. The discovery, that the principle of the Conservation of Energy was not incompatible with the Carnot cycle, removed the chief obstacle to the progress of thermodynamics, and the principles of that science were expounded in a masterly way in a paper by Lord Kelvin, published in 1851. This paper, which is remarkable for the dignity of its style as well as for its scientific importance, expressed the laws of thermodynamics by a few simple mathematical equations; it also introduced the absolute scale of temperature, and showed how this could be compared with the temperature given by a gas thermometer. Perhaps the most important contribution he made to the science was that

he saw more clearly than his contemporaries what a potent instrument thermodynamics is for the discovery of new properties of bodies. He saw that it follows from these laws, that certain properties of bodies must be connected in pairs, so that, if a body possessed one of these properties, it must possess also the other. Let me give you a simple example. It takes less work to stretch a soap film when it is hot than when it is cold, hence if we construct a little engine with a soap film for the working substance, if we stretch it when it is hot, and let it contract by the same amount when it is cold, we shall get more work when it contracts than we had to use to stretch it, so that it will act like an engine. Now thermal engines take heat from the boiler, so that the soap film when in the boiler, i.e., when it was being stretched, must absorb heat, i.e., its temperature must fall so as to allow the heat to run in. Thus, starting from the fact that the stiffness of a soap bubble is less when it is hot than when it is cold, thermodynamics shows that the bubble must cool when it contracts. Thus we see that thermodynamics doubles every discovery of the effect of temperature on bodies. Armed with this weapon, Lord Kelvin stalked through the various

branches of physics, thermo-electricity, magnetism and elasticity, gathering a rich harvest of fruit that had hitherto been out of reach.

Whilst in the midst of his researches on Thermodynamics he found time to make a discovery, which perhaps of all his discoveries has received the widest practical application. I mean the one contained in the paper on Transient Electric Currents published in 1853, in which he showed that electrical oscillations are set up when a charged electrical condenser is discharged, and calculated the time of the oscillations. This result is the basis of all the methods used for tuning in wireless telegraphy and broadcasting. I remember his telling me that he had never derived any benefit from this discovery until late in life, when he underwent, for the cure of his neuralgia, an electrical treatment based on electrical oscillations.

I shall make no attempt to recount his other discoveries in detail, suffice it to say that the output of papers continued without intermission until his death, that he made discoveries of fundamental importance in almost every branch of physics—the dynamics of solids and liquids, in electrostatics, in magnetism, the propagation of waves and ripples in water,

vortex motion, the equilibrium and wave motion of elastic solids, the stability of fluid motion, the equilibrium of a gaseous envelope, the size of atoms, experimental investigations on the electrification of air, and the tactics of crystals to which latterly he gave great attention.

The most striking feature running through all this work is, I think, his command and knowledge of dynamics. He had the engineer's intuition as to how matter in motion would behave, he knew by instinct and without mathematics what was likely to happen, though no one was more punctilious in working out the mathematics of the subject and obtaining numerical expressions which could be compared with the results of experiment. This intuition was, I think, to a great extent the secret of his wonderful success in applying mathematics to physical problems. He knew what to expect and this gave him the clue to the choice of the most suitable mathematical method for attacking the problem; he was a striking example of the truth of Bacon's dictum that the best results are obtained when a research begins with physics and ends with mathematics.

He looked at everything in his own way and this way was generally different from that of other people. It was this, combined with his enthusiasm, that gave the charm to his talk and lectures on physical subjects; these, though they might sometimes be discursive, and not infrequently very long, were never hackneyed. By passing through his mind, the subject, whether or not it became clearer to his hearers, was at any rate illuminated from a new angle.

As his way of looking at things was different from that of most people, it is not unnatural that he found it often difficult to understand the point of view of other writers, and that reading other people's work was not very congenial to him. He was an anomaly in physical science in that, though he was a good radiator, he was a bad absorber. As this led him to think out almost everything for himself, I think it was an advantage for the progress of science. The mind is rarely so active when reading as it is in original thought, and I think he got a firmer grip of a subject by working it out for himself from the beginning, than he would if he had followed the lead, and perhaps acquired the bias of, some previous investigator.

I have alluded to very many researches which Lord Kelvin carried to a successful conclusion. There was one, however, on which he was occupied off and on for more than 60 years, and for which he never got a solution which satisfied him—this was a theory of the luminiferous ether. He had, almost from his undergraduate days, set himself the problem which he described in his Baltimore Lectures, as that of explaining by the transverse vibrations of a continuous elastic solid called the ether, not only all the phenomena of light and radiant heat, but of electric and magnetic force, in a comprehensive etherial dynamics. He kept up his attack on this problem with splendid courage and ingenuity; he invented all kinds of elastic media, filled them with gyroscopes, tried if after all something like foam would not suit his purpose. The most interesting and fundamental of all these suggestions was that the ether was a "perfect" incompressible fluid full of vortex rings. He always, it may be remarked, pictured the ether as something which had very close analogy with ordinary matter. Time after time he thought he was quite close to success, but some flaw always appeared, and in 1896, after 50 years' work, he writes: "I now abandon

everything I have thought or written about the ether." This investigation of the ether is the "most strenuous effort" referred to in his speech at his Jubilee. "One word characterises the most strenuous of the efforts for the advancement of science that I have made perseveringly for fifty-five years—that word is failure. I know no more of electric and magnetic force or of the relation between ether, electricity and ponderable matter than I knew and tried to teach to my students of natural philosophy fifty years ago, in my first session as professor."

Lord Kelvin speaks of his life-long work on the ether as a failure. There is a well-known fable, where a man kept digging in his orchard to find gold which his father on his deathbed had said was buried there: he did not find the gold, but the digging produced a great crop of fruit. If Lord Kelvin did not find the solution of the problem of the ether, he found a great many other things, and of that crop of 661 papers enumerated in the excellent bibliography at the end of Silvanus Thompson's life of Lord Kelvin, no insignificant number arose from his work on the ether.

It might seem that a frontal attack on a problem so gigantic as that just indicated was

foredoomed to failure, but it must be remembered that when Lord Kelvin began his work, and for long afterwards, the problem seemed much simpler than we now know it to be. Everyone believed then, that the Undulatory Theory of Light supplied a complete geometrical description of the nature of light, though it might not account for the physics of its production or propagation. The geometrical representation given by the Undulatory Theory corresponded exactly with that of the transverse waves in an elastic solid. Thus, from this point of view, the research was comparatively simple; it was to find some kind of elastic medium which would suppress the longitudinal waves, permit of transverse waves, and allow bodies to move freely through it. A passage in the preface to the Baltimore Lectures is interesting in this connection. He says: "My object in undertaking the Baltimore Lectures was to find out how much of the phenomena of light can be explained without going beyond the elastic solid theory. We have now our answer—everything non-magnetic, nothing magnetic." I think this applies with still greater force if we substitute electric for magnetic in the preceding paragraph. For researches on the electrical

properties of light have shown that the undulatory theory as it stands is not, by itself, able to explain these properties, which point to a state of things much more analogous to that indicated by Newton's Corpuscular Theory, according to which, the energy of the light is concentrated in small nuclei and not spread continuously through space as in the Undulatory Theory. This corpuscular view is complementary to the undulatory theory, for, whereas it explains many of the electrical properties of light, it fails to explain the optical phenomena such as interference and diffraction; the undulatory theory, on the other hand, gives a complete explanation of the optical effects, but fails with the electrical. It would seem as if each of these theories indicated a part, but only a part, of the structure of light, and that as the corpuscular theory suggests light contains nuclei in which the energy is concentrated, the energy in each nucleus is related to the frequency of the light; but this is not all, for these nuclei generate electrical waves of the type assumed in the electromagnetic theory of light; these waves accompany the nucleus and though they possess but little energy themselves, yet they, by their electric and magnetic forces,

determine the path of the energy of the nucleus. This part of the structure of light is represented by the undulatory theory.

The elastic solid theory of the ether was introduced by Lord Kelvin for the purpose of explaining the phenomena of light; in his opinion, it was from the properties of light that we might expect the most direct evidence of the nature of the ether, when this was known a theory of electricity would naturally follow. When Maxwell introduced the electromagnetic theory in which light is regarded as an electrical phenomena, which makes optics appear as a branch of electricity, it must have appeared to Lord Kelvin as if the cart had been put before the horse; on his view it was the business of light to explain electricity, not that of electricity to explain light. I think the reason he did not advocate the electromagnetic theory more warmly (he never, I think, attacked it directly) was that he was always hoping to get something which, from his point of view, would be much more fundamental.

Those in the audience who, like myself, began to study dynamics in the last quarter of the last century must have a lively recollection of Thomson and Tait's "Natural Philosophy," a book

which had a profound effect on the study of dynamics in this country. It was quite different from other text-books. Speaking from my own experience, I should say that the points which attracted us most, were the introduction of the great general methods of dynamics, such as Lagrange's Equations and Hamilton's Principle of Varying Action, instead of a large number of special methods each designed to solve problems of the appropriate type in the shortest possible time. We were fascinated by the properties of gyroscopes, which were developed to an extent so far beyond anything we had hitherto met with as to be a revelation of new wonders; then again the dynamics and physics were always kept in the fore-front and not subordinated to the mathematical analysis. Let me give an illustration; in most of the Cambridge text books and in the Mathematical Tripos at this time, the discussion of a problem usually ceased when an equation connecting a number of symbols had been found. What the dynamical consequences of this equation might be was not as a rule considered, in fact the work left off just where it really ought to have begun. In Thomson and Tait all this was changed, the equations were squeezed and squeezed until

all the dynamics and physics they contained had been extracted. There was a kind of fascination, of glamour, about the book—as indeed there was about many things connected with Lord Kelvin—which kept us working at it in spite of its difficulties, for, with all its merits, the book is not easy reading.

As an appendix to the Natural Philosophy, he reprinted his paper first published in 1862 on the age of the earth; he shows in it how, from the present distribution of temperature in the earth, it was possible to work backwards and estimate its temperature at previous epochs. He showed that, if there were no internal sources of heat, the temperature 100 million years ago must have been so high that animal life would be impossible. This estimate brought him into conflict with the geologists, who required far longer than this for the development by evolution of the animal kingdom. The discovery of radioactivity shows that there is an internal source of heat and thus invalidates his conclusion.

It was the laying of the Atlantic Cable that first brought Lord Kelvin prominently before the notice of the general public. In his paper published in 1855 "On the Theory of the

Electric Telegraph" he worked out the theory of the transmission of electric signals along cables, and showed that the retardation of the signals was proportional to the square of the length of the cable. His connection with the actual laying of the cable began in December, 1856, when he was elected to the Board of Directors of the Atlantic Telegraph Company as the representative of the Scottish shareholders in that company; he held no technical position. The plan to be adopted, a very bad one, had already been practically decided, so that at first there was little he could do; he did, however, make tests of the conductivity of the copper and was the first to discover that different samples of commercial copper differed enormously in electrical conductivity. The first attempt to lay the cable was made in August, 1857, and Thomson went out on the Agamemnon, one of the cable-laying ships, though not in any official position; the cable parted in water of 2,000 fathoms and the expedition returned to England. Before the next attempt to lay the cable was made, Thomson, who saw the necessity for having a much more sensitive detector of electric currents than the one adopted by the official electrician to the

company, had designed the celebrated mirror galvanometer, where the current was detected by the deflection of a beam of light reflected from a very light mirror with a small magnet at the back. This invention was of primary importance for the successful working of the telegraph. In 1858 another attempt to lay the cable was made, Thomson again going out on the cable ship, and on August 3rd an uninterrupted cable stretched across the Atlantic. This naturally was the occasion of great rejoicing both here and in America. Unfortunately the cable began to deteriorate almost from the time it was laid and failed altogether on October 20th, 1858. The matter was again taken up, and in this attempt Thomson took the leading part in the electrical matters, the successful completion of the cable in July, 1866, was very largely due to his ability and courage.

It was a marvellous achievement on his part. When his connection with telegraphy began, his experience had been confined to the laboratory; he had to surmount without previous training all those difficulties which are met with when work is developed from the laboratory to the engineering scale, all those considerations about finance, ease of construction and freedom

from danger of breakdown, which make the work of the engineer so much more harassing than that of the experimenter. Above all, the engineer has to work with others, and his success depends to a large extent on his ability to keep in adjustment and in good working order that most capricious of scientific instruments—man. All these difficulties were overcome triumphantly and William Thomson showed that he was a great engineer as well as a great physicist.

Another service he rendered to telegraphy was the invention of the syphon recorder, which automatically registered the messages by an ink mark.

Among the most important things he did for electrical engineering was the design and construction of instruments for the accurate measurement of electrical quantities. For many years we relied on his instruments for all such measurements; if we wanted to measure a current we used a Thomson galvanometer, if a difference of potential, a Thomson electrometer and so on.

It was mainly due to him that the British Association Committee on electrical standards was appointed in 1861, a committee to whom we

owe the initiation of the determination of those fundamentally important quantities, the values of electrical quantities in absolute measure. He himself devised perhaps the most celebrated of all the methods used for this purpose, that of the determination of the absolute measurement of resistance by means of a spinning coil.

Lord Kelvin was a keen yachtsman and at one time spent much time at sea on board his yacht, the Lalla Rookh; he was thus naturally interested in navigation. To be interested in a thing was, with Lord Kelvin, synonymous with discovering something new about it, and a high naval authority has said that he regarded Lord Kelvin as the man who had done the most for navigation in our time. The Kelvin compass, the depth sounding machine with piano wire instead of rope, his work on tides and the construction of a tide predicting machine, were his most important contributions to navigation.

The Baltimore Lectures, a course of lectures given at the John Hopkins University, Baltimore, are of great interest, and, in their way, unique. They were not prepared beforehand. I believe, on good authority, that he had not always decided on the subject when he set out for the lecture-room. They were "thinkings

aloud" rather than ordinary lectures. Here we get, not the finished building, with the scaffolding all down, but the scaffolding itself going up and being pulled down again when it is not right. This book and, perhaps, even to a great extent, the lithographed shorthand reports of the lecture, give the most intimate revelations I know of the working of a great mind.

Lord Kelvin's services to science were not confined to his own discoveries and inventions; for more than half a century his personality and enthusiasm initiated and stimulated the work of many others. When he visited a laboratory, he would talk with each of the workers about his experiment; his kindness and obvious interest in what they were doing stimulated and encouraged them to renewed efforts, they were better physicists after his visit than they were before, because they had a new interest and a greater belief in the importance of their work. These qualities were nowhere more conspicuous than at the meetings of Section A of the British Association. He would stay, generally accompanied by Lady Kelvin, from the beginning to the end of the meeting, bubbling over with interest and enthusiasm, saying something suggestive and ingenious on nearly every paper,

filling the meeting with life and interest and inspiring and encouraging the younger men in a way no one else could approach.

We are commemorating to-day the memory of one to whom British science owes much of its prestige, who by methods all his own made vast and important additions to our knowledge, who is the outstanding figure in the union of theory and practice, and who has left us an example of unremitting, untiring devotion to a great ideal.

SIR RICHARD GLAZEBROOK: I have one other duty to perform, and I ask you to assist me in doing so. It needs no words of mine, I am sure, to induce you to pass a very hearty vote of thanks to our lecturer for all that he has told us.

The motion was carried with acclamation.

The Proceedings then terminated.

IN MEMORIAM : KELVIN
1824-1924

BANQUET

AT THE

CONNAUGHT ROOMS, GREAT QUEEN STREET, LONDON

JULY 11TH, 1924

ADDRESSES

(UNREVISED)

THE RT. HON. THE EARL OF BALFOUR
K.G., O.M., F.R.S
IN THE CHAIR

THE TOASTS of "His Majesty the King" and "Her Majesty the Queen, Queen Alexandra, H.R.H. The Prince of Wales, and other members of the Royal Family" were proposed by the Chairman, and accorded musical honours.

"IN MEMORIAM: KELVIN, 1824-1924"

THE CHAIRMAN, who was received with loud applause on rising to propose the above toast, said: My lords and gentlemen, I rise to ask you to drink in honour of the great occasion which has brought us here together to-day. One hundred years ago Lord Kelvin was born. In that hundred years science has made undreamed of strides, and it may truly be said that in more than fifty out of those hundred years Lord Kelvin proved himself to be a leader of rare originality and unfailing industry, and of an enthusiasm for the cause of science which has never been surpassed (applause). Throughout those fifty years he was occupied in teaching science, in developing science and partly, at least, in making practical applications of science for the great work of human progress.

I think it difficult, and perhaps unprofitable, to compare century with century, but I would certainly venture to say that, whatever may be said in other walks of human endeavour, whatever may be said with regard, for example, to literature or to politics, as regards science the century which ended in 1824 was far less prolific in great advances and great developments than the century which is now ending in 1924. If I am right in that, as I think I am (though there may be gentlemen here who would be prepared to dispute it), there is another cognate proposition which I am sure nobody here would dispute, that as regards the application of science to the material progress of humanity, there is absolutely no comparison between

the two epochs which I have, for obvious reasons, rather arbitrarily chosen.

Between 1724 and 1824 there were great discoveries, there were great additions made to our knowledge in physics and chemistry, but I doubt whether any of the inventions that marked that century could very properly be described as due directly to the disinterested investigations of men of science into the constitution of the universe in which we live. The century which is now drawing to its close, the century which followed 1824, is, however, full of the applications of an abstract, pure science to the arts and to the life of civilisation (applause). What was more characteristic, perhaps, of Lord Kelvin than of any other man of science of whom we have knowledge—except, perhaps, Archimedes, who lived a long time ago—was that he almost instinctively applied, or felt disposed to apply, the knowledge which the pure study of natural law gave him to the needs and to the happiness of mankind. He was not merely a great man of science; he was a great inventor, and he had an instinctive knowledge of the way in which physical discovery would lead to industrial progress (applause). We in this country, especially under the stimulus of the great gathering which is now taking place at Wembley, are apparently turning our attention to the use of electricity for the transmission of power. I think if you look back you will find a speech of Lord Kelvin's, made on the immediate inspiration of an observation of Siemens. You will find a speech of his upon the transmission of power—no doubt light also, but principally power—delivered in 1875, which really contains all that any budding orator in the House of Commons or elsewhere need know about the value to mankind of power, whether derived from the fall of water at Niagara or from the smaller replicas of Niagara which happily exist elsewhere than in the United States. He dwelt on all that, and he recommended

what I understand is the last recommendation of the last investigators into this question—that power stations should be situated at the mouth of coal mines, for the obvious reason that while coal costs a great deal to transport, electricity, when you have once got a rather costly plant in operation, costs comparatively little for mere transmission to considerable distances. If I fail in the physical accuracy of my exposition, you will remember I am a layman, and that a certain amount of blundering is not only permissible, but almost becoming (applause). The speech to which I refer was a vision of the future. It was one of those intuitions of genius which came naturally to Lord Kelvin. Besides that, as we all know, Lord Kelvin was an actual practical inventor of machines that paid—a quality not always found in ingenious inventions—(laughter)—but one which, apparently, his natural gift enabled him to attain. We all know what he did as regards the compass, as regards the tides, as regards deep-sea soundings, as regards calculating machines, and so on; and those who wish to have further and better information upon those subjects should consult the reports of the admirable address made by my near neighbour, the Master of Trinity, only a few hours ago (applause).

My lords and gentlemen, it is certainly true and abundantly proved that Lord Kelvin had these great practical gifts, very rarely, I think, associated with the highest type of scientific mind. Though he had these great practical gifts, do not let any man fall into the error of supposing that Lord Kelvin was ever faithless to his first and last love, that of the growth of knowledge of nature. He was an inventor by accident; he was a man of science by birth (applause). It is really as a man of science that I think he is, and that I am sure he ought to be, chiefly honoured. For fifty years he unremittingly pursued a great ideal. For fifty years everything connected with the growing sciences and growing development of physical knowledge

—electricity, magnetism, and the rest—absorbed his attention. What might, perhaps, appear to a superficial observer to be the tragedy of his life, if indeed tragedy can be associated with so great, so prolonged, and so successful a career, was that he had laid before himself, apparently in his very earliest years, an ideal object of pursuit at which he was always aiming, a height which he was endeavouring to climb, and a height which, indeed, was worthy of the greatest efforts of the greatest men, but which he felt at the end of his career he had not reached, and perhaps not even approached as nearly as the sanguine hopes of his earlier years had promised; which of us, indeed, is likely to go down to his grave in any age feeling that all the hopes of his youth have been amply fulfilled?

He made a speech towards the end of his career which has become famous—famous, at least, to all who are interested in these subjects—in which, when he laid down his professorship at Glasgow, he used the word "failure." The Master of Trinity referred to this; it has been referred to, I think, in all accounts of Lord Kelvin, and it is right that it should be referred to. Yet what a paradox, and in one sense what a sad paradox, that word implies! The whole world of science, from all quarters of the globe, was represented to congratulate Lord Kelvin on the occasion of his resigning his professorship after fifty years of brilliant and almost unexampled scientific work. Representatives of science from all over the globe were there to tell him of his success, and he replied by talking of his failure. My lords and gentlemen, I think that failure was in itself and by itself a mark of the greatness of the man (applause). He had put before himself this hope, this ideal, this summit of Mount Everest, or whatever metaphor you choose to use, with regard to that which is lofty and difficult of attainment. He had hoped to bring together all that was known of electricity, of magnetism, of the constitution of the

atom, of the nature of the ether, to show their interconnection and to make them, as it were, part of one organic whole. He felt, and I suppose he felt rightly, that he had not himself attained that great object, an object which in its absolute perfection and completeness we may still be far from having reached. At all events, he looked back upon the fifty years of his professorship and thought that more should have been accomplished in that direction by himself than he could flatter himself he had done.

Lord Kelvin was very critical of himself, and as the Master of Trinity with admirable delicacy and admirable wit explained to us yesterday, was not always receptive himself of the ideas of other people. This had the double result, as I think, of making him feel that he had not done the great work which in fact he had done, and made him perhaps underrate the dawn of that new physics which was taking place under his eyes. In one sense that may seem a rather melancholy result of a great life, but if we look below the surface I think that was not so. Lord Kelvin did not make the great synthesis which he had hoped, but every man who has contributed to the cause which Lord Kelvin had at heart has been Lord Kelvin's pupil (applause). Every one of those who have added so immensely in the last quarter of a century to our knowledge of the inner structure of the world in which we live has had Lord Kelvin for his master (applause). Though Lord Kelvin may not have fully appreciated the work which his pupils did before his eyes, and could not, of course, foresee the magnificent work which has been done since his death, nevertheless, when the scientific historian looks back upon the hundred years the end of which we are now celebrating, he will most assuredly say that the man who has contributed the most—I do not wish to make comparisons, so let me say the man who has contributed as much as anybody else, be he whom he may—in that century to the

scientific triumphs which have crowned its labours, in spite of the failure which Lord Kelvin himself so rashly proclaimed, was Lord Kelvin. His unceasing labours, his untiring and enthusiastic pursuit of scientific physical truth, have contributed to this new physics to a degree which those who themselves are the creators of the new physics would, I believe, be the very first to acknowledge (applause).

My lords and gentlemen, we are here to celebrate the career of a very great man. The diminishing band of those who knew him personally—of which I am proud to think I am one—will never forget the personality of the man, his simplicity, his intellectual eagerness, the total absence of anything in the nature of jealousy in his character, the charm of his personality (applause). We remember him, and we shall remember him until we die, and we shall always find it difficult to communicate our impressions of him to those who never knew him, and to whom we endeavour to give some impression of what the man himself was. It is a hopeless task. We who make the endeavour know that we must fail, but where I am certain history will not fail is when it surveys the progress of science, and when it realises that in the progress of science is bound up the progress of civilisation. When history, in that spirit, surveys the career of the great man who was born a hundred years ago, it will say that he bore at least his full share in the great work which that hundred years has accomplished, and that he deserves the gratitude of all those whose labours are built upon his discoveries. He will take his place amongst the immortals of science, the men to whom the future will look back as the founders of that sure and certain knowledge of the fabric of the world in which we live, on which surely must be based the greater part of our hopes with regard to the material advancement of humanity (applause).

My lords and gentlemen, I ask you in grateful silence to drink to the memory of the great man who was born one hundred years ago.

"DELEGATES TO THE KELVIN CENTENARY"

SIR RICHARD T. GLAZEBROOK, K.C.B., F.R.S., in proposing the toast, said: Those of us who were present yesterday at the ceremony which took place in the hall of the Institution of Civil Engineers, had in their hands a paper which I now hold here, and have realised who the delegates are, what their importance is, and why they have come to this country. Yesterday we received gratefully through them the addresses that they had brought with them, testifying their appreciation of our great master and teacher, Lord Kelvin. To-day I wish to give to them a message of thanks to carry home to those who sent them to this country, a message of thanks for the appreciation they have shown, and for the honour they have done to one whose name deserves all honour. I would also refer not only to the delegates who presented addresses yesterday, the delegates from nearly all the countries of Europe, but to those who have come to us from our own brethren across the seas, and whose addresses I was not able to stay to receive, as I had originally intended to do, owing to lack of time. Then again we have with us delegates from many of our own institutions and bodies, particularly connected with Lord Kelvin.

Perhaps one may ask what it is that has led to this great assembly of people, all of whom are well known in their own countries, and many throughout the world, for their work in science and in engineering. What is it that has led them to come here on this occasion, to be present to-night? You, my Lord,

have, I think, answered that question. Those of us who are mainly interested in science, and in the advancement of science, have realised that the foundations of nearly all we have learnt rest on the work of Lord Kelvin. In the first place, our friends have come here from admiration of that work, to show their appreciation of all it has meant to them and to their countries. Perhaps also they have come from some kind of feeling of what the world would have been like had Lord Kelvin never lived and worked. Try to think of it without the C.G.S. system of units, without our knowledge of the importance and value of the second law of thermo-dynamics, without any real information as to what goes on when an alternating electrical current circles round a wire—producing, as we now know, all the phenomena of wireless telegraphy—without the Atlantic cable, the mirror galvanometer, without the compass or the deep-sea sounding gear. All those we owe to Lord Kelvin, and it is in part, I think, because of the appreciation of the world of this fact that delegates have been sent by their societies from every country to visit us to-day.

It is a tribute also, I think, to the man himself. We have heard just now from our chairman something of his personal qualities, his boyish enthusiasm for investigation and research, his keen appreciation of any real advance made by any true student of science, however humble, his inspiring criticism, and his always ever-ready help. All these and more are reasons why the delegates have come, why we are here to-night, and why I am standing here to ask you to drink their health. Science, as we were told yesterday, is international. We are reminded of it daily. The very names, as Sir Joseph Thomson states, that occur in connection with electrical science bring that to our mind—the ohm, the ampere, the volt, the farad, the henry—all international names. It is realised that

while Kelvin's work was the outcome of his scientific ability, of his keen enthusiasm, and of his desire to advance knowledge; and while, of course, he was pleased and gratified at the results that work brought to himself, it was not only for himself that he worked; it was not only for his country that he worked; it was for the world at large, for the advancement of knowledge, for the benefit of mankind. For those reasons we believe that you gentlemen are here to-day (applause). One cannot too greatly emphasise the truth that science is international, and that we cannot work by ourselves, but depend on the help, support and encouragement we get from our fellow-workers throughout the world. My Lord Chairman, we live in troubled times. Is it vain to express the hope that the amity and friendship that we men of science feel we owe to the international character of our work may, in due time, penetrate more widely and influence the world in other walks of life? (applause).

I ask you to drink to the health of the delegates to the Kelvin Centenary, and I ask them to take back, each to his own country, our message of thanks, our expression of keen appreciation for the honour that they have done to Lord Kelvin, and to us, by coming here, and for the distinction they have given to the ceremonies which have been organised to celebrate this occasion.

I will couple with the toast the names of two of the most distinguished of those here present. First of all, there is Dr. Elihu Thomson, the Kelvin medallist of yesterday, a great American citizen, and a Britisher by birth (applause). He is the doer of deeds which have given to American electrotechnics the pre-eminence they may now claim, and the founder of great institutions in America—the Thomson-Houston Company and the great laboratories of the General Electric Company. I think we may feel confident that the success of those works and of that laboratory is due

in no small measure to the fact that Dr. Thomson has realised that the true foundations of industrial success are based deeply on pure scientific progress and advance (applause). You have shown by your applause that you appreciate the fact that I am to ask Dr. Thomson to reply to this toast.

I also wish to couple with the toast another name—that of Professor Luigi Lombardi (applause). He is here as the representative of a much older civilisation, as a delegate from the Reale Accademia Nazionale dei Lincei, of Rome, which is the oldest scientific society in the world—(applause)—a society that claims among not, perhaps, its founders, but among its earliest members the great predecessor of Newton—Galileo. From that time onwards the Society has contributed in very many ways to the advancement of science (applause). Professor Lombardi himself was for long years a distinguished professor of electrotechnics in Naples, and he now holds a similar post in Rome.

I ask you to drink the health of the delegates to the Kelvin Centenary, coupled with the names of Dr. Elihu Thomson and Professor Luigi Lombardi.

The toast was enthusiastically received.

DR. ELIHU THOMSON, who was received with loud applause on rising to respond, said: I consider it one of the misfortunes of my life that I did not stay in England and become the pupil of Lord Kelvin. My august namesake has that advantage over me. I did, however, in a later year, have occasions when I met Lord Kelvin. On one occasion I remember very distinctly, Lord and Lady Kelvin were visiting the works of the General Electric Company, and they were going on to Boston near where works of the General Electric Company have existed for something like thirty years. I had the most charming interview during that trip of about

six hours on the train with Lord and Lady Kelvin. We discussed many matters in which we had a common interest, and it was significant of his simplicity of action and of thought that he every now and then took out his little note-book and noted down what he may have thought he was learning—I do not think it was much. I may mention another little incident which was characteristic of the man. He had heard of the recently established subway electric tramways—subways in which the tramway cars passed down an incline and went underground, and then came up again. He would not go with Lady Kelvin to the hotel at Boston until he had gone down into that subway and thoroughly investigated it. That shows his interest in engineering, a form of engineering based on the sciences of which he was a master.

I realise it is quite a task to respond for such a body of delegates as are represented here, and I can only do it in the most general terms. I have been asked to respond in part to the toast which has been proposed, and I esteem it a privilege to voice on behalf of the delegates to the Kelvin Centenary their thanks for the kind privileges, attentions, and other evidence of cordial hospitality which have been accorded to them all in their dealings with their hosts in London. To the efforts of these hosts must be attributed the success of the celebrations which have been held.

It can be said of very few men, if any, other than Lord Kelvin, that they covered three-quarters of a century in study and work in connection with science. His actual work may have covered a shorter period, but we can readily understand a precocious youngster, such as he was, thinking and preparing from the earliest days for what was to come later. His earlier work was done at a time when facilities were meagre, and these he had to create. The present opportunity of uniting in celebration of the centenary of his birth the representatives of contemporary science in its

most advanced forms, together with representatives of the civil, mechanical, electrical and mining societies, representing all the great and important services which science and engineering can render to humanity, is, to say the least, an unusual one. It may be an augury of the increasing part the engineer of the future must and should have in shaping the policy of nations intelligently for the good of the world. It may be that through science and engineering and their influence, we may look for the establishment of harmonious relations between the nations, avoiding the terrible waste of valuable lives and valuable resources which is always the result of war (applause).

I may say in conclusion that we look to England for great advances in science. We are justified by the fact that there are many followers of Kelvin himself, many pupils of Kelvin, in this land. We appreciate the work of those great leaders, many of whom follow Kelvin as their standard-bearer, and who have in recent years led us so far forward in our understanding of the relations which electric and magnetic forces bear to the inner nature of all the forms of matter and of energy in the universe. I feel sure that all the delegates to the Kelvin Centenary celebration will join with me in response to the toast in expressing their thorough appreciation of the efforts and kindly spirit shown by their hosts on this memorable occasion (applause).

PROFESSOR LUIGI LOMBARDI, who was received with loud applause, said: In the first place, I should like to thank very cordially the President of the Kelvin Centenary Committee for the opportunity he has kindly given me of speaking on this memorable occasion. Not having the privilege of speaking your beautiful language very well, I fear I will not be able to express worthily my mede of appreciation for the great honour conferred upon me. This honour is not due in any way, I am sure, to my

merits; it is, I believe, conferred on account of the very friendly relations which prevail between our technical and scientific institutions (applause), and especially between the Royal Society of England and the Reale Accademia Nazionale dei Lincei of Italy (applause). Similar good relations exist between the British Institutions of Civil, Electrical and Mechanical Engineers and the Italian Associations, including the Society for the Improvement of the Sciences, all of which I have the honour to represent.

Italian scientists and technicians are in entire agreement in recognising the gigantic amount of scientific work accomplished by Lord Kelvin and the inestimable value of the admirable contributions he brought to the universal knowledge. He was remarkable for the vigour of his theoretical conceptions, and for the clearness of his practical insight. Professor Garbaso, a Fellow of the Royal Academy, who was the reader of a beautiful memorial address, after Lord Kelvin's death, before the Italian Electrical Association (which reserved for Lord Kelvin the first place amongst its honorary members) was not able to find, in the long history of science, anyone to be compared with him but the great Greek Archimedes, the same person to whom Lord Balfour referred this evening (applause).

The Roman Academy, on which is reflected the glory of Volta and Galileo (applause), wanted to elect Lord Kelvin as an honorary member, and extended to him when he came with Lady Kelvin to Italy, a very cordial and memorable reception. He was himself a good friend of Italy, and showed great interest in our natural and artistic beauties as great as in our technical and industrial undertakings. On the 11th July, 1892, when the first large transmission of electric power in Europe was put in action between Tivoli and Rome, the Anglo-Roman Illuminating Company received from him and a dozen other well

known English electricians, a sympathetic telegram, of which I am able to give you the exact text. It said: "English electricians send greetings to electricians of Italy on completion of splendid enterprise of Tivoli, and wish them every success" (applause). Besides Lord Kelvin's name the telegram was signed by many other well known men, including Colonel Crompton, who is present this evening. I am very glad to meet Colonel Crompton here to-night, and I ask permission to present him with a copy of this historic document (applause).

On behalf of Italian electricians, every one of whom would like to be considered to-night your spiritual guests, in responding to the beautiful toast proposed by Sir Richard Glazebrook, I beg you to accept our best thanks, greeting and good wishes for now and for ever (applause).

"THE CHAIRMAN"

DR. A. E. KENNELLY, in proposing the toast of "The Chairman," said: A grateful and welcome task is mine. It is my great honour and my unwarranted honour to have to propose the toast of "The Chairman." Before doing so, however, I beg permission to mention a few of the reasons for which we should especially acclaim him. He belongs not only to us, but to many other kinds of assemblies. He is a Parliamentarian of fifty years' enviable record (applause). We Americans especially revere him because he is the Chancellor of Cambridge University, and Cambridge University is ever foremost in the thoughts of our academicians because after that name our Cambridge University was founded by John Harvard, one of her illustrious sons (applause). We honour him also because he has been (if he is not now) Rector of Glasgow University, and because it is in honour of Glasgow, as well as of its illustrious professor, the world-famed Kelvin,

that we are met here to-night. We also honour him in our country because in 1917 he headed the British Mission (applause), and it pleases us to remember that among the dozen—no, the baker's dozen—of honorary degrees, the thirteen doctors' degrees that I believe have been awarded to our distinguished Chairman to-night, the last was awarded by our Columbia (applause).

He is not only endeared to America but to all the countries represented here because of his scholarly, literary and philosophic writings (applause). Wherever thinkers are found, and they are found all over the civilised world, the name of Balfour is revered. In tendering to him this toast and our recognition, we beg also with the responders to the last toast to include with him, and through him, our appreciation of our hosts on all those splendid occasions in which we have so recently participated. Courtesy has linked with courtesy and hospitality dovetailed with hospitality, so that it is hard indeed even to distinguish so great a personality as our Chairman this evening from the personalities which have preceded him at similar gatherings. We all feel, I am sure, deeply indebted to our hosts for the way in which they have given us so royal a welcome. The precision of the arrangements and the businesslike character of the administration has won our highest gratitude and has left us poor of encomium.

In a world of scattered and sparse populations we know it is sufficient for every man to use his own muscular power to drain his own swampland, but when the density of the population increases and villages become towns and towns become cities it becomes ever increasingly necessary to accumulate power, and the power of applying power becomes a sovereign power. It was, perhaps, Lord Kelvin's crowning invention that he invented the direct application of intellectual

power to the power of serving humanity. When he commenced his memorable life's work the power of the universities, the power of the mathematicians, the power of the great thinkers was indeed connected to the power of applied mechanics and of engineering, but so remotely and through so long a rope over so many rusty guides and pulleys that the friction between the two was enormous. It was his signal gifts of great knowledge, great intellectual power, great energy and great appreciation of practical necessities which removed that long rope and brought intimate contact about. The power of the universities and of the royal societies, and of learned societies and intellectual forces throughout the world, is now applied directly on the same shaft as the generators to the terminals, of which are connected the distributing systems of humanity. It seems to me that not only in our halls, in our conferences at Wembley, but in the great Exhibition of Wembley itself, we see a manifestation of the direct results of this connection of mental to material power, because I think we have all been struck with the very large proportion of the Wembley Exhibition which is explicitly devoted to engineering. I believe that the engineering building at Wembley is the largest reinforced concrete building in existence, and not only are the parts which are explicitly devoted to engineering so very large at Wembley, but also a large proportion of those which are not recognised as engineering buildings may be said in a broad sense to be engineering in fact. We may say that not only in the conference halls have we tried to show some little appreciation for the work of our great master Kelvin, but that all Wembley is in a certain sense an indication of what he has accomplished, leading us to follow in his footsteps. Moreover, looking beyond Wembley at the world at large we find science directly bearing upon industry in so many fields and through so many channels, that I

think we may well say of Lord Kelvin " Si monumentum requiris circumspice " (applause).

It is with great pleasure, therefore, that we delegates and representatives owning a common C.G.S. system in which Lord Kelvin, as Lord Balfour mentioned, took so prominent a part, we who have come here on this unique occasion, desire to express to our Chairman our affection, our earnest thanks and our great admiration (applause).

The toast was drunk with musical honours.

THE CHAIRMAN, who was received with loud applause on rising to respond, said: Dr. Kennelly, my lords and gentlemen. You will not think I am using language of formal politeness when I say how deeply moved I am at the kind way in which you have received the toast which, in such generous terms, Dr. Kennelly has proposed to you. I thank you most heartily on my own behalf, but perhaps as Dr. Kennelly has referred to other hosts who have had the great gratification and honour of offering hospitality to our guests from other countries and from overseas, you will allow me to express also, if I may, their appreciation of the recognition which their efforts have universally met with on the part of our visitors. I beg to thank you on their behalf and on mine for the kindness which you have shown on this great historic occasion, which only reflects and reduplicated the kindness which you have shown on other similar occasions which have taken place during this memorable year.

The Proceedings then terminated.

ADDRESSES COMMEMORATIVE

PRESENTED BY THE DELEGATES FROM
FOREIGN COUNTRIES AND
BRITISH DOMINIONS
TO THE
COUNCIL OF HONOUR

JULY 10TH, 1924

(ARRANGED IN ALPHABETICAL ORDER OF COUNTRIES)

THE AUSTRALIAN NATIONAL RESEARCH COUNCIL

The AUSTRALIAN NATIONAL RESEARCH COUNCIL welcomes the opportunity, which it owes to your committee, of doing homage to the memory of one of the greatest men of science of modern times, WILLIAM THOMSON, BARON KELVIN OF LARGS.

His fundamental researches in thermodynamics, electricity, and magnetism, and many other branches of physical science, will always be remembered, for they were essential contributions to that unprecedentedly rapid advance in human knowledge and understanding, which characterised the later part of the nineteenth century and the years that have followed.

Almost equally characteristic of the same period have been the wonderful growth and development of European, and especially British, communities in the furthermost parts of the earth, which would have been impossible but for the successful application of science to the practical problems of navigation and electrical communication. Here, also, KELVIN stands out pre-eminently as one of the most illustrious benefactors of mankind.

The people of Australia share with the rest of the civilised world, its admiration of his scientific genius, and gratitude for his teaching. They also have especial cause to pay tribute to the great inventor, to whom much of their material and social advancement is due.

D. Orme Masson,

President

THE INSTITUTION OF ENGINEERS AUSTRALIA

The president, council, and members of the INSTITUTION OF ENGINEERS, AUSTRALIA, welcome the opportunity of adding their tribute to the memory of LORD KELVIN, whose work in the fields of research and industry has been of such immense value to the world's progress.

Situated 12,000 miles from her motherland, Australia, sixty years ago, was dependent on intercommunication requiring nearly four months to accomplish, until KELVIN with his cable inventions broke the barrier of time, and made a message a matter of moments. Therefore, we in Australia revere his memory because the development of his theories and inventions has largely led to the removal of the handicap of Australia's isolated geographical situation.

For the Council of THE INSTITUTION OF ENGINEERS, AUSTRALIA

L'ACADÉMIE ROYALE DE BELGIQUE a eu l'honneur de compter LORD KELVIN pendant plus de trente ans, parmi ses associés étrangers.

Elle a déjà pris part en 1896, à la cérémonie de son cinquantenaire de professorat et s'est associée, en 1908, au deuil de l'Université de Glasgow qui perdait en LORD KELVIN son éminent chancelier.

Les relations de l'Académie avec son illustre associé étaient intimes et fréquentes; sa bibliothèque renferme de nombreux travaux de LORD KELVIN, offerts par celui-ci.

L'Académie Royale de Belgique tient donc particulièrement a participer à la célébration du centenaire de sa naissance en s'y faisant représenter par un délégué. Elle veut montrer ainsi son admiration pour le génie du grand physicien, honorer la mémoire du savant dont les travaux et découvertes sont appliqués partout pour le plus grand bien du monde entier—et donner, en même temps, à la Société Royale de Londres un témoignage de ses sentiments d'affectueuse confraternité.

THE ENGINEERING INSTITUTE OF CANADA

The members of the ENGINEERING INSTITUTE OF CANADA are honoured, in the opportunity which has been offered to them, of paying a public homage to the memory of LORD KELVIN.

The study of LORD KELVIN'S life, and more particularly of his achievements, leaves one in admiration at the comprehensiveness of his genius, and at the untiringness of his energy. It would require a mind almost as well developed as that of LORD KELVIN himself to appraise at their true value his discoveries and his inventions.

It is a matter of pride to us, as Canadians, in our loyalty to the British Empire, to feel that as we have derived our language, our literature, and our traditions from the mother-country, so do we owe also, to the great men of science in Great Britain, the broad foundation upon which our engineering knowledge rests. We realise fully that, to the conception of the master minds of this country which made possible the great development of our modern civilization, and particularly to that supreme genius whose memory at this time we so greatly cherish, the world owes a great debt of gratitude. We cannot forget that it was LORD KELVIN'S research work on the application of electricity to submarine telegraphy which made possible the laying of the transatlantic cable. Thus it was he who enabled us to establish rapid communication with the motherland, drawing us closer together in the bonds of empire union.

As Canadians also, we like to remember that SIR WILLIAM THOMSON was a member of the International Niagara Falls Commission, established in London in 1890 for the purpose of studying the methods in use in the old world for the production and for the transmission of electricity. In this, as in

every problem he approached, he left the lasting mark of the master mind, and again it can be truly said that we owe to him a heritage which has made possible the great power development which we in Canada to-day enjoy.

Vice-President of the Engineering Institute of Canada

THE ROYAL DANISH ACADEMY OF SCIENCES AND LETTERS

The ROYAL DANISH ACADEMY OF SCIENCES AND LETTERS is thankful for having been offered this opportunity of paying its tribute of respect to the memory of LORD KELVIN, to whose genius and untiring life-long work, not only the pure and applied sciences, but all mankind are so greatly indebted.

He gave us electric images and taught us how to use them, he gave us the word energy, and he gave us much of our knowledge about it.

He greatly extended the boundary of natural philosophy in every direction. He determined the way in which electric currents are propagated through long cables, and he taught us how to telegraph through long submarine cables, thereby making an effective connection possible between the old and the new worlds.

He taught us how, accurately, to measure electric power. He greatly facilitated navigation in deep as well as in shallow waters.

The ROYAL DANISH ACADEMY OF SCIENCES AND LETTERS is justly proud of having had, for thirty-one years, LORD KELVIN as one of its foreign members, and sends its congratulations to the Royal Society of London at the centenary of the birth of one of those illustrious British men of science who have always been the glory of your Society, and to whom physical science is in such an overwhelming debt.

Copenhagen.

Vilh. Thomsen

President

Martin Knudsen

Secretary

At the centenary of the birth of LORD KELVIN, THE INSTITUTION OF DANISH CIVIL ENGINEERS feels it a dear duty to pay its respects to his memory.

To LORD KELVIN we owe much of what we know about thermodynamics, and about electricity and magnetism. And he taught us better than anybody else how to use this knowledge in order to solve the greatest engineering problems in telegraphy, in navigation, and in electric power distribution. He will for ever stand as one of the world's greatest engineers, and, therefore, his memory will always be cherished by all who are devoted to the art and science of engineering.

Copenhagen.

President

Secretary

L'ACADÉMIE DES SCIENCES DE PARIS est heureuse de s'associér aujourd'hui à la commémoration de la naissance de celui qu'elle compta longtemps parmi ses Associé's étrangers. Aucun nom de savant étranger n'est plus connu en France dans le domaine scientifique que celui de SIR WILLIAM THOMSON et de LORD KELVIN. Le génie decegrand physicien s'est montré capable des spéculations les plus profondes et les plus hardies, en même temps qu'habile aux applications étudiées dans leurs détails les plus minutieux.

De bonne heure THOMSON fit preuve d'un rare talent d'invention dans ses études sur l'électrostatique, et ses mémoires sur la chaleur le mirent bientôt au premier rang des adeptes de la philosophie naturelle. À son nom est attachée la notion d'une échelle absolue de température, et ses mémoires sur l'énergie utilisable et sur la tendance universelle dans la nature à la dissipation de l'énergie mécanique restent à jamais mémorables. L'effet THOMSON en thermoélectricité est classique parmi les physicians, non moins que l'expérience faite avec Joule sur le refroidissement des gaz.

Votre illustre compatriote a été un précurseur dans la question des oscillations de l'électricité. La propagation de l'électricité dans un cable a fait aussi de sa part l'objet de longues études, où l'on ne sait ce que l'on doit le plus admirer, de la pénétration du théoricien ou de l'habileté de l'expèrimentateur et du technicien. Une des conséquences en fut l'établissement de communications télégraphiques entre l'ancien et le nouveau Monde, qui eut un si grand retentissement, et rendit populaire le nom de SIR WILLIAM THOMSON. Comment ne pas rappeler encore ses nombreux instruments de navigation, répandus dans toutes les marines.

Le Traité de Philosophie Naturelle de THOMSON et TAIT a fait l'objet des méditations des géomètres et des physicians, et tous les esprits curieux des recherches cosmogoniques ont admiré ses travaux sur la chaleur solaire et sur les marées de la surface terrestre. La tendance naturelle de son, esprit le portrait à rechercher dans le visible une représentation de l'invisible. Presque tous ses travaux sur la constitution de la matierè et de l'éther sont guidés par cette penseè, et c'est de là que naguirent son hypothése célèbre des atomes tourbillons et sa conception si originale de l'éther girostatique.

LORD KELVIN trouva le bonheur dans la recherche et le culte du vrai, et rien n'affaiblit jamais sa foi dans la science. A un autre point de vue, il peut être proposé en exemple. Cet homme de pensée fut toute sa vie un homme d'action. Jamais l'union entre la science et l'industrie ne fut mieux réalisée que chez ce grand physicien. Sa vie scientifique est un modèle, unique peut-être, pour ceux qui ne veulent pas séparer la pratique et la théorie.

C'est avec une profonde émotion que l'on regarde dans l'Abbaye de Westminster la dalle qui recouvre les restes de LORD KELVIN. Sur le tombeau voisin de Newton, on lit que c'est un honneur pour le genre humain qu'un tel homme ait existé. On aurait pu écrire en toute vérité sur la tombe de LORD KELVIN, que c'est un honneur pour l'angleterre qu'un de ses savants ait, dans l'ordre théorique comme dans l'ordre pratique, exercé une telle maitrise, et contribué avec tant d'éclat aux progrès de la philosophié naturelle.

Paris. Le Secrétaire perpétuel de l'Académie.

Emile Picard

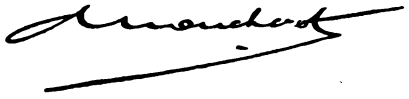
LA SOCIÉTÉ FRANÇAISE DES ELECTRICIENS a tenu à s'associer à l'homage de reconnaissance que les savants et les technicians du monde entier apportent aujourd'hui dans cette cérémonie à l'un des meilleurs enfants de la Grande Bretagne, et je suis fier de la représenter en cette circonstance.

LORD KELVIN OF LARGS est un des rares hommes qui aient marqué une époque, à la fois dans l'évolution des connaissances scientifiques et dans celle des moyens de travail de l'humanité; sa silhouette se détache fortement sur l'aurore de l'industrie électrique, et c'est parce que cette industrie a bénéficié, comme la Science, des productions de son génie que les techniciens et les ingénieurs viennent joindre leurs voix à celles des savants et des philosophes de tous pays.

Les Ingénieurs de l'industrie des courants de faible puissance ne peuvent oublier qu'il est en quelque sorte le créateur de la télégraphie sous-marine; ceux de la télégraphie sans fil, qui dispute aujourd'hui l'empire des communications mondiales à la précédente, qu'il est l'auteur du magnifique mémoire de 1853 " on transient electric currents " qui expliqua et formula le phénomène de la décharge oscillante. Les ingénieurs de l'industrie des courants de grande puissance ne peuvent oublier ses travaux relatifs à la localisation des courants variables à la surface des conducteurs, aux conditions économiques d'établissement des lignes de transport d'énergie: la règle si claire qui détermine la densité de courant à adopter, critiquée parfois par ceux qui n'en ont pas très bien compris l'interprétation physique mais qui l'appliquent sans le savoir, montre jusqu'où le portait sa sagacité dans l'ordre même des applications. Enfin les ingénieurs électriciens de toutes catégories connaissent ces nombreux instruments de mesure, dont il a doté

l'industrie à ses débuts et dont beaucoup d'autres dérivent, et dans lesquels on ne sait ce qu'il faut le plus admirer, de l'adresse dans l'application des principes scientifiques ou de l'ingéniosité développée pour vaincre les difficultés pratiques. Ils ne peuvent oublier non plus la part considérable prééminente, qu'il prit dans les discussions du Congrès de 1881 qui donna au monde les systèmes de mesure et les Unités adoptées internationalement.

LA FRANCE et la Ville de Paris peuvent être fières d'avoir eu l'honneur de donner asile à ce mémorable Congrès, qui réunit alors une élite de savants comme on en voit peu, et dont celui qui s'appelait alors SIR WILLIAM THOMSON était parmi les plus glorieux.



KONINKLIJKE AKADEMIE VAN WETENSCHAPPEN TE AMSTERDAM

THE DUTCH ACADEMY OF SCIENCES is happy to be among those who, on the occasion of the centenary of his birth, pay a tribute to LORD KELVIN'S memory, expressing the feelings of admiration and respect that are due to the great physicist.

His work, extending over more years than are allotted to most men, was one great and glorious effort to unveil Nature's secrets, and to use the knowledge thus gained for important applications. In all departments of physics, and in many of the sciences closely connected with it, he left the marks of his genius, whether, as a pioneer, he opened new lines of thought and investigation, or attained the full ripeness of brilliant results. So he came to be honoured all over the world as a great master of science.

The Academy gratefully remembers that it was allowed to inscribe LORD KELVIN'S name on the list of its foreign members, and the encouragement which he gave to Dutch physicists will not be forgotten.

Amsterdam.

The Council of the DUTCH ACADEMY OF SCIENCES.

F. A. F. C. Went

President

Bolk

Secretary

THE INSTITUTION OF ENGINEERS, INDIA

The INSTITUTION OF ENGINEERS (INDIA) is greatly honoured by your invitation to participate in the KELVIN CENTENARY CELEBRATIONS.

We are a catholic body representing the many varied interests of the engineering community in the great Indian Empire. Few of us enjoyed the privilege of personal acquaintance with LORD KELVIN, yet we all realise to the full that our work to-day is made possible by his untiring study and research, by the brilliance of his genius, and by his generosity in divulging for our use the immense store of his knowledge.

Though we are of many nations, and of a diversity of scientific interests, we are united in acknowledging our obligation and in honouring the great scientist who was born one hundred years ago.

We esteem as a privilege, the opportunity you have given us of adding our quota to the tribute which the world pays to-day to the memory of LORD KELVIN.

Calcutta.

THE INSTITUTION OF ENGINEERS (INDIA)

Hey Burkinshaw.

Delegate

LA REALE ACCADEMIA NAZIONALE DEI LINCEI

LA REALE ACCADEMIA NAZIONALE DEI LINCEI ha l'onore di ringraziare il COMITATO PER IL CENTENARIO DI LORD KELVIN del cortese invito fattole di partecipare alle solenni onoranze da tributarsi alla memoria del Grande Fisico.

Questo scienziato illustre, che la nostre Accademia ha il vanto di avere ascritto fra i suoi Soci, contribuì potentemente, per oltre tredici lustri, al progresso di tutti i rami della Filosofia Naturale, mentre il Suo genio immaginava nuove e mirabili applicazioni pratiche delle scoperte teoriche. Infatti il Suo desiderio insaziabile di sapere lo spinse a scrutare i segreti piú riposti dell'Universo, e la Sua mente fertile d'ingegnosi, trovati, riveló agli uomini i mezzi per volgere a loro profitto le forze della Natura.

Tali sentimenti di ammirazione e di gratitudine, della Patria di Galileo e di Volta, rivolgono riverenti verso la memoria di LORD KELVIN, quanti amano il sapere e il progresso dell'Umanità.

Rome.

NATIONAL RESEARCH COUNCIL OF JAPAN

The NATIONAL RESEARCH COUNCIL OF JAPAN has the honour of presenting a Memorial Address on the occasion of the celebration of the Centennial Anniversary of the birth of LORD KELVIN, one of the most illustrious sons Great Britain ever produced. She is justly proud of the brilliant success he has achieved in illuminating the intellectual world as well as in paving the way to the material progress of modern civilisation.

Born at a time when the tide of physical research was just beginning to turn, and the innate relations of natural phenomena began to be elucidated on dynamic principles, he propounded the fundamental doctrine of energy, and taking it as his compass, directed his course to bring heat, light, electricity and magnetism into a correlated whole; his ever-active mind penetrated into the depths of atomic structure and soared to the remotest confines of the universe, and of cosmic evolution. In his "Nineteenth Century Clouds" he has frankly told his contemporaries the difficulty of reconciling the different properties attributed to ether, which question is absorbing the attention of scientists even at the present day. In the applications of exact science to social needs, he was a pioneer; the Atlantic cable immortalised his name, and his various measuring instruments bore testimony to the manifoldness of his inventive genius.

The NATIONAL RESEARCH COUNCIL OF JAPAN specially desires to recall with gratitude the interest he took in developing physical science and in encouraging research in this part of the world. At the time when Japan was remodelling her education on modern lines, she was fortunate to have his eminent disciples as organisers. Dyer, Gray, Ayrton, Perry, Ewing and Knott, personally recommended by LORD

KELVIN himself, came to the Far East, and by their personal examples, inspired the young students with the spirit of research and love for the pursuit of truth, a spirit which sprang from the soul of the Great Master. And when these students came to Glasgow to receive direct instruction from SIR WILLIAM, he was their father and friend, guiding them by hand through the untrodden realms of physical research.

All who came into immediate touch with him must have been convinced of the advantage and necessity of the metric system of weights and measures, of which he was an "uncompromising advocate" as one of his esteemed biographers says. Three years ago, the Japanese Government passed a law making compulsory the use of that rational system of units, and it is just a week ago that that law came into force. This is one of the seeds, so abundantly sown by the prophet of science, which took root in an unexpected soil.

In tendering its best thanks for the kind invitation to participate in the commemoration of the birth of the great physicist, the NATIONAL RESEARCH COUNCIL OF JAPAN is happy to pay its due tribute in recognising its obligation to the Great Master, and to send as its delegate one of his most devoted pupils. His deeds will ever remain deeply imprinted in the memory of the members of this Council, and of other scientific bodies of Japan, and it is their hearty wish that Great Britain shall never cease to bring forth such glorious sons as LORD KELVIN to shed everlasting light on the cause of science and civilisation.

K. Furuichi

President of the National Research Council of Japan

LA DIRECCIÓN DE ESTUDIOS
GEOGRÁFICOS Y CLAMATÓLOGICOS
MEXICO

I have the honour, an honour which I deeply appreciate, to represent officially the DEPARTMENT OF GEOGRAPHICAL AND CLIMATOLOGICAL RESEARCHES, a branch of our Mexican Ministry of Agriculture and Development, at the Commemoration Festival of LORD KELVIN, in which that Department has been so courteously invited to participate by the Centenary Committee.

This festival will be a deserved homage to the memory of the great man who, born as WILLIAM THOMSON, departed from life as LORD KELVIN, after having gathered such high honours as were due to his beneficent work, the results of which are already inscribed on a chosen page of the golden book of humanity. There his name is enshrined for ever, amongst those of the greatest benefactors of our race, which has derived such enormous advantages from his patient scientific investigations, his contributions to theoretical truth, his marvellous inventions in applied physics, more especially electricity.

Gifted with a great strength of will and a wonderful intellect, one of the very few men who have been able, with equal ease, to probe the deepest abstractions of science or to turn their minds to practical applications of everyday use, he devoted his life, partly to the study of higher mathematics, partly to countless improvements and inventions in electricity (submarine cable, electrometer, etc.), and other branches of physics.

It can be said of him that his clear mind acted as a powerful searchlight, which he flashed into the dark recesses of the unknown, showing new and safer paths to knowledge. Thanks to him, crooked roads have been straightened, and the way made easier for present and future explorers.

No praise, therefore, could be too high for the life begun a hundred years ago, of your great LORD KELVIN; I would rather say "our," for men of that stamp, who have served the whole of humanity, are not, perhaps, so much citizens of a particular country, as of the world itself, and their glory is no less universal than immortal.

LORD KELVIN has passed away; but his work survives him, and his memory will be treasured by all, as long as there are men with hearts capable to feel a pious and grateful admiration towards those who have so faithfully and efficiently laboured for their benefit. May the remembrance and glory of this great man endure for ever!

Consul-General of Mexico for Great Britain and Ireland

NORSKE INGENIÖRFORENING

On the occasion of the Centenary Celebration of the birth of LORD KELVIN, the SOCIETY OF NORWEGIAN ENGINEERS, sending their sincere regards and congratulations to the Royal Society, respectfully and thankfully do homage to the memory of this remarkable philosopher and investigator, far-seeing and creative physicist.

For den NORSKE INGENÖIRFORENING

W Darre-Jenssen.

President

J. Bassøe H. Gulstad

Sverre Gjestland

General Secretaire

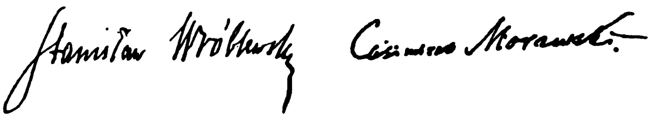
Quod quidem, domini praestantissimi, humane et benigne nos invitare dignati estis, uti una Vobiscum magni neque annorum oblivione oblitterati viri memoriam celebraremus, cuius nataliciorum centesima sollemnia hoc anno festive peragere in animo est, maximas Vobis agimus gratias. Etenim GUILELMUS THOMSON, baro KELVIN, qui Vestrae praeclarae Societati olim praefuerat, nostrae vero Academiae per longum temporis spatium socius exstiterat, primarii et praecipui inter exploratores naturae auctoris profecto meritus est gloriam et exemplar nobis praestitit imitandum, scientiae decus illuxit genuinum neque unquam consilio suo et doctrina admirabili nos carere passus est. Animus eius agilis, perspicax et audax semper antecedebat aequalium conatus, semper diversarum scientiae partium progressui praeerat. Ille nempe demonstravit, terram nostram a longo iam tempore refrigescere, quantopere vero iam obriguerit, definivit, ille undarum maris momenta descripsit oceanique fluctus, solis quoque vires computavit et tempora, quibus lux eius suffectura esset, emensus est; eruere denique studuit, unde mundi forma et ordo exorta essent, et fata, quae ei imminerent, secure divinabat. Arcana electrica et magnetica naturae perscrutatus mirandas illas vires emetiri et accurate indagare nos docuit. Itaque auctor exstitit eius scientiae, quam postea Vestrae gentis illustris homo, Jacobus Clerk Maxwell, tot tantisque decoravit triumphis. Egregie porro de conformatione materiae, de vera aetheris qualitate commentus est quaedam ac laudabiliter cum aeternis aenigmatibus in mundo latitantibus tamquam alter Titan colluctatus est. Fuitque ille non solum eximius investigator et dis putator subtilis, homo ingenii admodum feracis, sed insuper bonus vir dicendi peritus, veritatis et iustitiae cultor, qui universos

humanitatis sectatores suosque familiares arcto sibi devinxit amore.

Et meruit profecto, qui successor celeberrimi Newtonis in Regia Societate gubernanda praeesset; quaeque illum virum in Abbatia Westminster praedicant verba, eodem iure ornare possint huius sepulcrum, qui caeli arcana nobis revelavit " sibi gratulentur mortales, tale tantumque exstitisse humani generis decus."

Itaque dignemini, collegae summopere venerandi, benigne accipere nostras gratulationes et plurimam quoque salutem.

Cracoviae.



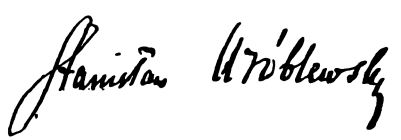
POLISH ACADEMY OF SCIENCES AND LETTERS

Men of science and of learning in Poland, venerate deeply the memory of LORD KELVIN, the great master who, by unparalleled discoveries and generalizations, has benefitted science and advanced mankind. They not only admire the exploits of the intellectual giant, they remain affectionately attached to the remembrance of the noble man who, to some of them, was a kind and helpful teacher and adviser, who held before the world grand ideals of truth and research.

The POLISH ACADEMY OF SCIENCES AND LETTERS desires to thank the Chairman and members of the KELVIN CENTENARY CELEBRATION COMMITTEE for the opportunity afforded of paying a tribute of gratitude and respect to the memory of the great philosopher and leader.

Cracow.

President of the Polish Academy of Sciences and Letters



General Secretary of the Polish Academy of Sciences and Letters

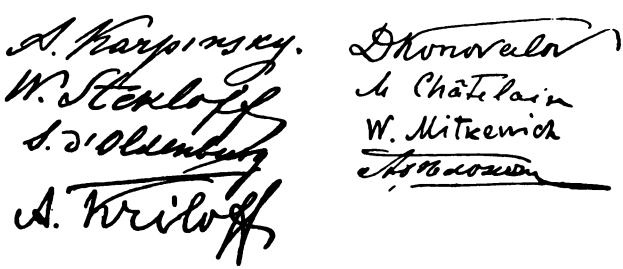
RUSSIAN ACADEMY OF SCIENCE

The history of science has always known quite exceptional personalities, who have taken the lead in scientific discovery, and have shown the ways and methods of work for generations to come. One of these world's luminaries has been LORD KELVIN. His work and ideas have given us a new definite conception of the universe, unifying the different branches of the science of Nature. We see in him the great mathematician, one of the greatest scholars in physics, the philosopher and the man of technical applications of scientific discoveries. His creative mind applied these splendid achievements to technical uses in common life.

For fifty years the great personality of LORD KELVIN, with his deep and quite English practical intellect, has been a leader in the domain of Science, influencing at the same time all technical discoveries.

Generations of Russian scientists and practical engineers have imbibed his ideas, considering him always as their great teacher.

To-day, when the representatives of all countries meet to celebrate this centenary, all Russian scientific men and engineers send their greetings to the mother country of the great man. May the same spirit of sincere fellowship, which unites to-day the scientific workers of the whole world, form closer bonds between them for the benefit of humanity.



REAL ACADEMIA DE CIENCIAS EXACTAS, FÍSICAS Y NATURALES DE MADRID

LA REAL ACADEMIA DE CIENCIAS EXACTAS, FÍSICAS Y NATURALES DE MADRID al adherirse a la celebracion del centenario del nacimento de LOR KELVIN, expresa sus sentimientos de admiracion al considerar la labor científica del eximio profesor en multiples ramas de la Filosofia Natural; labor que fué no sólo enseñanza teorica de principios científicos, sino origen de importantes aplicaciones prácticas utilizadas hoy dia por la Humanidad que rinde tributs de agradecimiento al sabio Maestro.

Madrid.

El Presidente

THE ROYAL SWEDISH ACADEMY OF SCIENCE

THE ROYAL SWEDISH ACADEMY OF SCIENCE, which for fifty-six years had the honour and gratitude of counting WILLIAM, LORD KELVIN among its members, finds in that fact a special occasion to embrace with enthusiasm the opportunity provided by you, to learned societies in various countries, of paying to the memory of that distinguished scientist well-merited homage on the hundredth anniversary of his birth.

The scientific achievements which, seventy-three years ago, led our Academy to associate with itself a scientific student who was then only in his twenty-seventh year, were worthy predecessors of the long line of ingenious researches and pioneer discoveries which won for their author the reputation of being the greatest physicist of his time, and which will stand out to future students of science as brilliant and encouraging models, difficult though they may be to equal.

Stockholm.

On behalf of
THE ROYAL SWEDISH ACADEMY OF SCIENCE

Sven Hedin *President*

H. G. Söderbaum *Secretary*

INGENIÖRS VETENSKAPS AKADEMIEN

On the occasion of the hundredth anniversary of the birth of that famous scientist, LORD KELVIN, the ROYAL SWEDISH INSTITUTE FOR SCIENTIFIC-INDUSTRIAL RESEARCH sends an expression of its lively appreciation of the great significance of LORD KELVIN'S extensive and prolific production, not only for the further development of science itself, but also for technics and industry; not only for the benefit of his own mighty British country, but as a blessing for the whole of humanity.

Stockholm.

For the INGENIÖRS VETENSKAPS AKADEMIEN

H Sleijel

President

Axel Lindhow

Director

If it is true that scientific work generally is of international importance, then in a still higher degree is it the case with regard to technical research and its results. Among the famous men to whom the civilized world is indebted in this respect, LORD KELVIN, whose memory is being celebrated to-day, is certainly one of the most prominent. The results he obtained by numerous ingenious theoretical investigations, which were utilized by him in a series of practical inventions, have given him for all time, a most honoured place in the history of technical sciences. The ASSOCIATION OF ENGINEERS AND ARCHITECTS in Sweden—in which country technical achievements have been highly appreciated since early times—feels it an honour, as well as a welcome duty, to take part in the celebration of the centenary of LORD KELVIN'S birth, and to express their gratitude for his grand contribution in extending the knowledge of Nature, and the art of taking its powers into the service of mankind.

Stockholm.

Charles Häglerf

Vice-President

H. G. Ekman.

Secretary

LA SOCIÉTÉ HELVÉTIQUE DES SCIENCES NATURELLES

Obéissant à un devoir pieux, vous n'avez pas voulu laisser passer la date du centenaire de la naissance de LORD KELVIN sans rappeler sa mémoire et sans associer, par une pensée dont nous sommes personnellement touchés, le monde étranger au pays de naissance de votre grand citoyen.

Autant son départ, en 1907, laissa le sentiment d'une perte irréparable, autant, aujourd'hui, la célébration de son centenaire, la glorification de son œuvre, nous montre que son génie reste vivant, impérissable.

La Société Helvétique des Sciences Naturelles tient, elle aussi, à rendre un juste hommage au savant qui, par ses découvertes sans nombre, par la fécondite de sa pensée, par son influence sur le développement de l'humanité, appartient à cette humanité tout entière.

Nous n'oublions pas que, chaque jour, à chaque heure, à tout instant, les relations des hommes entre eux sont facilitées par les découvertes de LORD KELVIN, dues à son savoir, à sa clairvoyance et à sa ténacité au travail.

Il fut non seulement un chercheur, un industriel, un savant, un philosophe, mais encore celui que l'on peut glorifier per le titre de bienfaiteur de l'humanité.

Veuillez, messieurs, recevoir l'hommage de reconnaissance de tous les savants suisses et agréer l'expression de nos sentiments d'amitié.

Lausanne.

Au Nom de la Société Helvétique des Sciences Naturelles.

Le Président M. Lugeon

Le Vice-Président E. Wilczek.

Le Secrétaire Pierre Th. Dufour.

BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C., U.S.A.

It is with a peculiar sense of indebtedness to the pioneer spirit of the great KELVIN that I present this Address in behalf of the BUREAU OF STANDARDS, the national standardizing institution of the United States of America. This debt of honour is, for us, threefold.

In the first place, through his faith, his genius, and his perseverance, LORD KELVIN, more than any other one man made practicable the establishment of quick and reliable communication across the seas that separate us from you. Who can estimate the influence which this ready communication has exerted in creating that happy degree of mutual understanding, which places Britain and America side by side in time of danger, and has enabled us to round out a century of peace with every prospect of centuries more to come? As he has thus created a bond both material and spiritual between our country and yours, we claim a share in him as one of the great leaders of our English-speaking race, transcending national lines.

Besides this service of giving us better contact with the lives and culture of other nations across the seas, KELVIN played a part in the intellectual life of our own nation which was of far-reaching importance. He came to America at a time when most of its great universities were stagnant, but some were being stirred into a new life. His stimulating treatment of the problems of natural science roused into new activity the little group of men who were the nuclei of our later development. At the same time, the prestige of his name secured a respectful hearing from those who had the power to support the new scientific studies. The growth of research in our country which followed was certainly due in no small measure to his influence.

And finally, speaking particularly for the standardizing laboratory, one is continually amazed at the extent to which the work of the present day rests upon the foundations he laid. In electricity, our most fundamental instruments and methods perpetuate his fame; in heat, our basic temperature scale appropriately bears his name; while in optics his influence has been scarcely less important. Although he was a pioneer, the paths he trod were chosen with such an unerring sense that his successors have only to make them more smooth and broad, so that all may follow in his steps, and keep alive his spirit by searching out yet further ways into the world of things unknown that lies beyond.

And so we hail him as one of the great masters who showed us how to measure and how to build, how to discover Nature's secrets, and how to use them for the benefit of mankind. As the world moves on to better understanding, to deeper knowledge, and to greater wealth, our debt to KELVIN will ever grow.

E. C. Crittenden

AMERICAN SOCIETY OF CIVIL ENGINEERS

The AMERICAN SOCIETY OF CIVIL ENGINEERS desires to express the appreciation of its members for the great services of LORD KELVIN to engineering science.

The writer will leave to others the statement of LORD KELVIN'S services to the electrical, the mechanical and the mining engineer; because the broad fields of civil engineering are now becoming divided amongst specialists in electric science and arts, specialists in the science and arts of machinery, and the manufacture of power from fuel, and specialists in the sciences and arts of metallurgy, mining and geology.

In its present more popular and restricted sense, civil engineering still retains as particularly its own field the sciences and arts of building bridges and roads, of harbours, canals and railroads; of providing cities with their domestic water supply and their systems of sewerage and sanitation; the reclamation of marshes and of arid lands; the control of rivers in flood or in drought; and endless problems of water power, of dams, of great framed structures and of transportation.

It may be asked just what contribution did KELVIN make to solving the problems of these special fields of civil engineering, and why are we, who practice in these fields, so desirous of bringing our tribute here.

It is not so much because we recognise LORD KELVIN'S contributions to power development at Niagara, or the great utility of his tide-computing machine, his perfection of a mariner's compass, and his many aids to navigation, his improvement in the art of making soundings, his studies of waves and wave-wash in canals, as because we recognise in KELVIN the great leader in bringing together pure

science and applied science; of bringing the profoundest conceptions of science into the service of the constructive arts.

It was KELVIN, first of all the great leaders, who popularised laboratory methods. Until after his leadership, even the colleges where science was taught, forerunners of our present great schools of engineering, contained no laboratories for the use of their students. Now, laboratories for research abound in every line of industry, and in the service of each great centre of governmental activity. For KELVIN'S introduction and popularising of laboratory methods of teaching we are particularly grateful.

More than any of those who had gone before, KELVIN showed how greatly the civil engineer needed the service of profound mathematical analysis in some lines of problems, or the most delicate refinements of the physicist in others of his problems. He emphasised the importance of attention to minute quantities. He showed through a half century of teaching, and gave many practical examples, how the problems of "The Great Out-of-Doors" dealing with the greatest magnitudes and the most powerful forces, could be taken into the laboratory of the physicist or into the study of the mathematician for analysis and solution. Thereby in this broad and general way, by teaching the true scientific method of approach to a problem, even more than by attention to sundry important specific problems, he greatly aided the civil engineer towards "Directing the great sources of power in Nature for the use and convenience of Man."

Respectfully submitted on behalf of THE AMERICAN SOCIETY OF CIVIL ENGINEERS

BY: John R. Freeman, *Past President*

Special Delegate to the Kelvin Centenary Celebration

Although LORD KELVIN is largely associated in the public mind with the stupendous electrical progress of the past half-century, his grasp of physical laws and processes was so comprehensive, mechanical construction was so essential to the realization of his ideals, and his habit of complete and minute analysis in the design, and application of such construction was so keen that the mechanical engineer may bring to this occasion his tribute of gratitude and admiration, based upon real contributions by the master, to the founding and progress of his art.

At twenty-one we find him holding tubes and working an air pump for Regnault that he might have a view-point in the front skirmish line of scientific investigation.

It is significant of his interest and manner of thinking that he should have been so powerfully attracted at this period by Clapeyron's "Memoire sur la Puissance Motrice du Feu"; of his thoroughness and dogged persistency that he should have pursued for three years his search for a copy of Carnot's "Réflexions," upon which it was based, and that he should have become so potent an influence in resurrecting this treatise, published the year that he was born, and in establishing the modern conception of the nature of heat, and the science of thermodynamics.

To the growing understanding of the relation of heat to other forms of energy, he made many contributions, one of the earliest being his classical "Memoir on the Dynamic Theory of Heat," presented in 1851, when he was only twenty-seven years of age. In the same year he suggested the method, still connected with his name, of investigating the thermal properties of gases by forcing them through a porous tube.

Much of his thought was directed at the broader aspects of power production and the sources of terrestrial energy. In 1852 he discussed a paper on the air engine presented by Joule to the Royal Society, and himself presented to the Royal Society of Edinburgh a paper on the "Mechanical Action of Radiant Heat or Light on the Power of Animated Creatures over Matter, and the sources available to Man for the production of Mechanical Effects."

It would take too long to mention even his outstanding contributions to this underlying phase of mechanical engineering. As Dr. Silvanus P. Thompson has truly said, if his work in thermodynamics stood alone it would suffice to place his name as a natural philosopher beside that of Newton in its grasp of principles and generality of outlook.

Of practical applications of the mechanical laws and principles that he knew so well, there are many examples. In addition to his exquisite dealing with the complicated electric phenomena of the Atlantic cable, there was much in the physical problem of its placement that demanded new applications of mechanical principles, and his satisfactory solution of these problems led later to the invention of his deep-sea sounding apparatus. His marine compass is another instance of his analytical mechanical design, and in 1876-9 he invented a remarkable series of machines for the performance of complicated mathematical operations.

Many of his activities in this direction dealt with precise mensural determinations, and he wrote: "Accurate and minute measurement seems to the non-scientific imagination a less lofty and dignified work than looking for something new. But nearly all the grandest discoveries of science have been the rewards of accurate measurement and patient, long continued labour, in the minute sifting of numerical results."

In 1876 he served as Chairman of the Committee

of the International Centennial Exposition at Philadelphia, dealing with instruments of precision, research, etc.

In 1884, America had a delightful experience of him in the classical Baltimore Lectures, and in the early 'nineties he served America again as Chairman of the Niagara Commission, appointed to advise with regard to the development of power at Niagara Falls.

As Americans and as engineers, we are honoured by the privilege of adding our tribute of admiration and appreciation of those qualities that made the man in whose name we are assembled, outstandingly great.

President, American Society of Mechanical Engineers

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

WILLIAM THOMSON raised himself, by marvellous natural abilities and enormous energy, to a pre-eminent place among the world's engineers and scientists, enriching various fields of both fundamental and applied science in epoch-making ways. He was not only a great representative Britisher, but also a great world leader, renowned among all the nations of the earth. He received no less than twenty-one honorary doctor's degrees from Universities in various countries.

Of the 661 papers and literary contributions attributed to LORD KELVIN by his accomplished biographer, Dr. Silvanus P. Thompson, a considerable portion relate to electricity and its applications. His great work in developing electrostatic and electromagnetic measuring instruments, his revolutionising of both the theory and practice of long submarine-telegraph communication, and his contribution alike to the theory and practice of early electric power distribution, are well known to electrical engineers, and would have been sufficient to make the name of KELVIN famous, even if he had done nothing in those other great fields of knowledge and application, where his accomplishments are similarly conspicuous.

I deem myself highly privileged to participate on this great occasion, as the representative of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, in the company of distinguished representatives from other American National Engineering Societies.

A. E. Kennelly

Past President of the American Institute of Electrical Engineers

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS

The AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS thanks the engineering institutions of Great Britain that have so kindly and thoughtfully allowed it to participate in these celebrations, particularly as an American engineer and scientist has just been awarded the KELVIN medal.

The mining and metallurgical industries have profited greatly by the discoveries and inventions of LORD KELVIN, both directly and indirectly.

LORD KELVIN, then plain WILLIAM THOMSON, fitted up a laboratory in Glasgow, with apparatus for testing conductivity of copper. At that time, the importance of high conductivity of copper was not recognised. His apparatus was an improved Wheatstone Bridge of his own design.

This led to improvement in conductivity, so that to-day, 100 per cent. conductivity (Matthiessen Scale), is quite common.

He made investigations on the tensile strength of the armour for submarine cables. His testing apparatus for physical and electrical properties of metals entering into electrical construction have become standard.

A good story is told of the occasion of his journey to London from Glasgow to receive the honour of knighthood. He turned his classes over to an assistant named Day. Some wag wrote on the blackboard of the lecture theatre the following :—

" Work while you yet have Day, for when the Knight cometh, no man can work."

This is no reflection on his attitude towards his students, as he was beloved by them all.

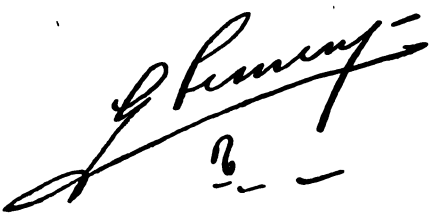
E. G. Mackenzie

Past President of the American Institute of Mining and Metallurgical Engineers

INTERNATIONAL ELECTRO-TECHNICAL COMMISSION

The INTERNATIONAL ELECTRO-TECHNICAL COMMISSION feels it an honour, as well as a duty, to take its part in the world's tribute to the memory of LORD KELVIN.

My colleagues of all nations desire to join with me in expressing their profound gratitude for the advice and support which LORD KELVIN, as its first President in 1906, gave to this world-wide movement in its initial stages, and which has played so great a part in whatever success the Commission has so far attained.



President

INTERNATIONAL CONGRESS FOR APPLIED MECHANICS

The INTERNATIONAL CONGRESS FOR APPLIED MECHANICS gathered at Delft from 22nd—28th April, which is attended by visitors from America, Australia, Belgium, Bulgaria, Germany, Egypt, England, France, Holland, Italy, Norway, Poland, Russia, Scotland, Spain, Switzerland, Tchecho-Slowakai, Turkey, on account of the 100th anniversary of the birthday of WILLIAM THOMSON, LORD KELVIN, to be celebrated within some months, wishes to express its feeling of deep admiration for the work done by this great genius in nearly all branches of science.

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KELVIN CENTENARY EXHIBITS

No.

1. Model of rotating coil apparatus for determination of the ohm.
2. Quadrant electrometer.
3. Absolute electrometer.
4. Portable electrometer.
5. Types of electrostatic voltmeter.
6. Types of mirror galvanometer, including the instrument used at sea by Lord Kelvin during the laying of the Atlantic Cable.
7. Early model of tide predicting machine.
8. Group of gyrostats and spinner, including spheroids with liquid interiors.
9. Early model of recording tide gauge. This instrument, which was the second constructed, and which was set up at the entrance to Queen's Dock, Glasgow, in 1882, is described in a Paper by Professor Sir William Thomson (Inst. C.E. Proc., Vol. 65).
10. Automatic curb transmitter.
11. Puncher for use with above.
12. Marine galvanometer.
13. Mirror speaking galvanometer.
14. Thomson and Jenkin slides. (Early pattern by C. and S. A. Varley).
15. The Kelvin gyroscopic combinations. These experiments were shown each year by Lord Kelvin to his classes.
16. Records and photographs.

The above exhibits were kindly lent by the University of Glasgow, the Clyde Trustees, the Institution of Electrical Engineers, the Eastern Telegraph Company, and Miss Agnes Gardner King.

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